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STATUS OF STOCKS OF SPINY LOBSTERS AT NECKER ISLAND AND MARO REEF, 1985

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INTRODUCTION

Commercial fishing for the spiny lobster, Panulirus marginatus, in the Northwestern Hawaiian Islands (NWHI) began in November 1976 when one vessel trapped lobsters at Nihoa and Necker Islands. In 1977, there were four vessels in the fishery trapping primarily in the southern end of the NWHI. Landings of spiny lobster for 1977 were 37.5 metric tons (MT) and by 1984 annual landings had increased to 290 MT. Recently the catches of slipper lobsters, Scyllarides squammosus and S. haanii, have increased so that now the fishery is a multispecies fishery. Although commercial catch and effort data have been available since 1983, due to changes in the type of traps and some selective effort for slipper lobsters, it is difficult to make inferences about the status of the spiny lobster stocks directly from trends in commercial catch and effort data.

In August 1985, a research cruise resampled the identical quadrants (which measured 0.1° on a side) at Necker Island, Maro Reef, and Laysan Island which had been sampled on research cruises in 1977 with the same type of wire mesh traps. In addition, a comparison of catch rates between the black plastic trap currently used by commercial fishermen and the wire mesh trap was made.

COMPARISON OF CATCH RATES BETWEEN 1977 AND 1985

In 1977, the commercial fishery for spiny lobsters was just beginning and effort was low. Thus the catch rates from the research cruises in 1977 reflect the unexploited standing stock. Catch rates (catch per unit effort (CPUE)) were measured as the number of lobsters caught per trap-night. The 1985 catch rates were compared with the 1977 catch rates with the model:

$$\text{CPUE (1985)} = \text{B CPUE (1977)} + \text{error}$$

where the coefficient B, which is the ratio of the 1985 CPUE relative to the 1977 CPUE, is obtained by regressing the 1985 catch rates on those of 1977 over the same quadrants at Necker Island, Laysan Island, and Maro Reef. The mean catch rates and the regression coefficient B for the 1985 catch rates regressed on the 1977 catch rates are presented in Table 1. Due to vessel problems the sampling time at Necker Island in 1985 was shortened and only two quadrants were sampled, so an error estimate was not obtained from the Necker regressions. The 1985 catch rates have declined to 40% of their 1977 level at Necker Island, 63% of their 1977 level at Maro Reef; the latter decline is statistically significant ($P<0.05$). At Laysan Island, which is a refuge and closed to lobster fishing, the 1985 catch rate was 62% of the 1977 level but due to the large amount of variation in the catch rates the reduction is not statistically significant. If it is assumed that catch rates are linearly related to standing stock, then these results imply that in 1985 the standing stock of the trappable lobster population has been reduced to 40% of its unexploited

Table 1.--Mean catch-per-unit effort (CPUE) in total number of lobsters per trap night from wire traps.

Island or reef	Spiny lobster CPUE 1977	Spiny lobster CPUE 1985	Ratio 1985 CPUE/ 1977 CPUE	(S.E.)	Slipper lobster CPUE 1977	Slipper lobster CPUE 1985	No. of traps 1977	No. of traps 1985
Necker	6.30	2.52	0.40	--	0.05	0.17	438	192
Laysan	2.64	1.63	0.62	(0.36)	0.09	0.10	229	376
Maro	3.29	2.07	0.63	(0.09)	0.16	0.15	223	379

level at Necker Island and 63% of its unexploited level at Maro Reef. The catch rates of slipper lobsters at these same sites are low and essentially unchanged over the same period.

Under the regulations of the spiny lobster fishery management plan (FMP) which went into effect in 1983, only lobster with carapace length (CL) equal or exceeding 7.7 cm could be harvested. A comparison of the catch rates at the same sites at Maro Reef, Necker Island, and Laysan Island for 1977 and 1985 is presented in Table 2. The 1985 catch rate of the harvestable size group was 26% of its 1977 level at Necker Island, 51% of its 1977 level at Maro Reef, and 75% of its 1977 level at Laysan Island. Again the decline in catch rates between 1977 and 1985 was statistically significant at Maro Reef but not at Laysan Island ($P<0.05$). The CPUE for the sublegal size group (7.0-7.7 cm CL) in 1985 was at 74% of its 1977 level at Necker Island and 92% of its 1977 level at Maro Reef, and 71% of its 1977 level at Laysan Island. Neither the decline in sublegal CPUE at Maro Reef nor Laysan Island was statistically significant.

Table 2.--Catch-per-unit effort (CPUE) for spiny lobsters for two size classes from wire traps.

Island or reef	Carapace length size class 7.0-7.7 cm				Carapace length >7.7 cm			
	CPUE 1977	CPUE 1975	Ratio 1985 CPUE/ 1977 CPUE	(S.E.)	CPUE 1977	CPUE 1975	Ratio 1985 CPUE/ 1977 CPUE	(S.E.)
Necker	1.27	0.94	0.74	--	4.92	1.28	0.26	--
Maro	0.37	0.34	0.92	(0.14)	2.93	1.49	0.51	(0.11)
Laysan	0.14	0.10	0.71	(0.40)	1.91	1.44	0.75	(0.35)

These catch rate trends imply that the legally harvestable population at Necker Island has been reduced to about one-fourth its unexploited level, and to about half its unexploited level at Maro Reef. When statistical variation is taken into account there is no evidence that the sublegal population at Maro Reef or Laysan Island has been reduced from that in 1977. An error estimate is not available for Necker Island where the sublegal catch rate has been reduced to 75% of its 1977 level. If this reduction is statistically significant it may be due to a number of factors, including mortality of the sublegals which are caught in traps and released, a decline in recruitment due to excessive fishing pressure which could substantially reduce the spawning stock, or direct fishing mortality on sublegals due to their retention in the catch.

Based on catch rate and length-frequency data, and a rather approximate estimate that the size at which 50% of the female population becomes sexually mature is 7.0 cm CL, it is possible to compute an index of the spawning stock biomass at Maro Reef and Necker Island in 1977 and 1985. At Necker Island the spawning stock biomass in 1985 was 25% of its 1977 unexploited level. However, the 1977 catch data at Necker Island appear anomalous since 70% of the animals caught were females while in 1985 the proportion of females in the catch was much closer to 50%. If the proportion of females is taken to be 50% rather than 70% of the catch for Necker Island in 1977, then in 1985 the spawning stock biomass is at 34% of its unexploited level. At Maro Reef the spawning stock biomass in 1985 is 61% of its 1977 unexploited level.

The Beverton and Holt yield equation can be used to estimate the relative fishing mortality which would produce the decline of the standing stock of lobster >7.7 cm CL observed in 1985 at Necker Island and Maro Reef. The two parameter estimates required by the Beverton and Holt equation are the ratio of natural mortality to growth and the ratio of length at entry to the fishery to asymptotic length. Based on tagging experiments at French Frigate Shoals it is estimated that the von Bertalanffy growth parameter K is 0.27/year for males and 0.35/year for females and instantaneous natural mortality is 0.4/year for males and 0.6/year for females, which result in estimates of the M/K ratio used in the Beverton and Holt equation of 1.5 for males and 1.7 for females (MacDonald 1984). The asymptotic length based on length-frequency samples is 12.3 cm CL for females and 13.6 cm CL for males at Maro Reef and 11.1 cm CL for females and 12.0 cm CL for males, respectively, at Necker Island. Based on a length of entry to the fishery of 7.7 cm CL the ratio of length at entry to asymptotic length is approximately 0.6 for males and females at Maro Reef and males at Necker Island and 0.7 for females at Necker Island.

The ratio of standing stock under exploitation relative to the unexploited standing stock as a function of fishing mortality relative to natural mortality and the length of entry relative to the asymptotic length is computed from the Beverton and Holt yield equation (Table 3). At Maro Reef the 1985 catch data estimate that the standing stock of the harvestable population (>7.7 cm CL) has been reduced to 51% of its unexploited level. From the Beverton and Holt yield equation when the length of entry relative to the asympototic length is 0.6 as it is for

Table 3.--The ratio of standing stock under exploitation relative to unexploited standing stock as a function of relative fishing mortality and relative length of entry to the fishery when the ratio of natural mortality to growth is 1.6.

Length of entry to fishery/asymptotic length	Fishing mortality/natural mortality			
	0.1	0.5	1.5	3.0
0.70	0.89	0.60	0.32	0.18
0.60	0.88	0.57	0.29	0.16
0.50	0.86	0.54	0.25	0.13

males and females at Maro Reef, the standing stock will be reduced to 57% of its unexploited level when fishing mortality is 50% of natural mortality. At Necker Island 7.7 cm CL corresponds with 0.6 of the asymptotic length for males and 0.7 of the asymptotic length for females. For the standing stock to be reduced to 26% of its unexploited level, as indicated at Necker Island from the 1985 catch rates, fishing mortality must be about 1.5 times natural mortality (Table 3). Thus if the reductions in catch rates are representative of changes of equal magnitude in standing stock, and these changes are due solely to fishing mortality, then the current level of fishing mortality at Maro Reef is 0.5 times natural mortality while fishing mortality is 1.5 times natural mortality at Necker Island or about three times that at Maro Reef.

TRAP COMPARISONS

At Maro Reef and Necker Island comparisons were made of the catch rates and size composition between the original wire mesh California traps used in the research sampling (which were used initially in the commercial fishery) and the recently introduced black plastic traps which are now the standard commercial traps. The comparisons were made by using strings of traps composed of an alternating sequence of the wire and plastic traps and fitting the regression model:

$$\text{CPUE (wire)} = \text{B CPUE (plastic)} + \text{error}$$

There was no difference between the two types of traps with respect to catch rates for spiny lobsters at Maro Reef and Laysan Island but at Necker Island the plastic traps caught about three times as many spiny lobsters than the wire traps. Further, the plastic traps appear to catch at least four times the number of slipper lobsters than the wire traps (Table 4). The size frequency of the catch for the two types of traps indicates that the plastic traps catch a greater proportion of smaller animals than the wire traps (Figs. 1-4). For example, at Necker Island where the average size of spiny lobsters is smaller than at most other islands, about 75% of the males and females caught in the plastic traps have a carapace length

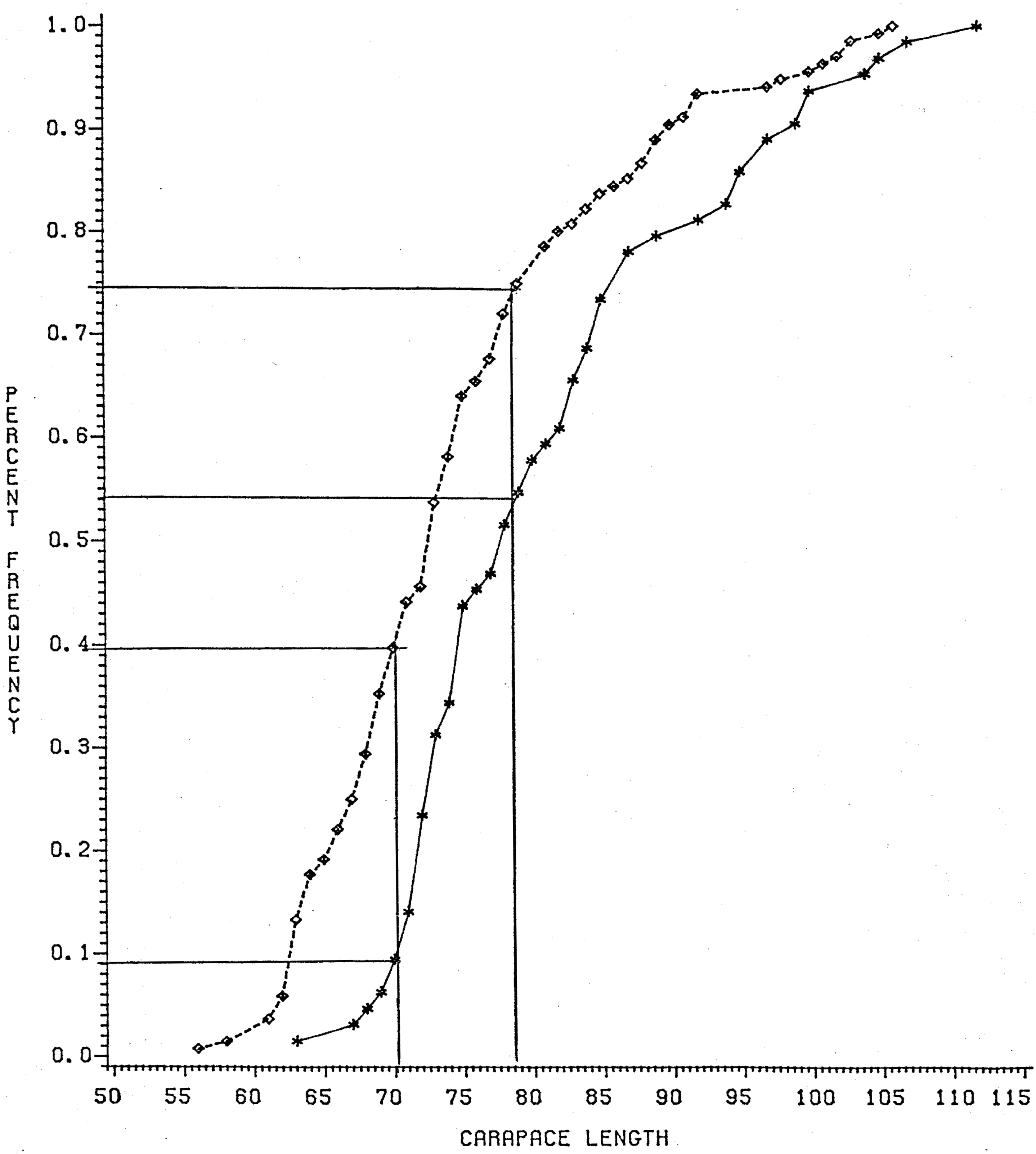

Figure 1.--Cumulative size composition of catches in wire and plastic traps for males at Necker Island.

WIRE TRAPS => SOLID PLASTIC TRAPS => DASHED

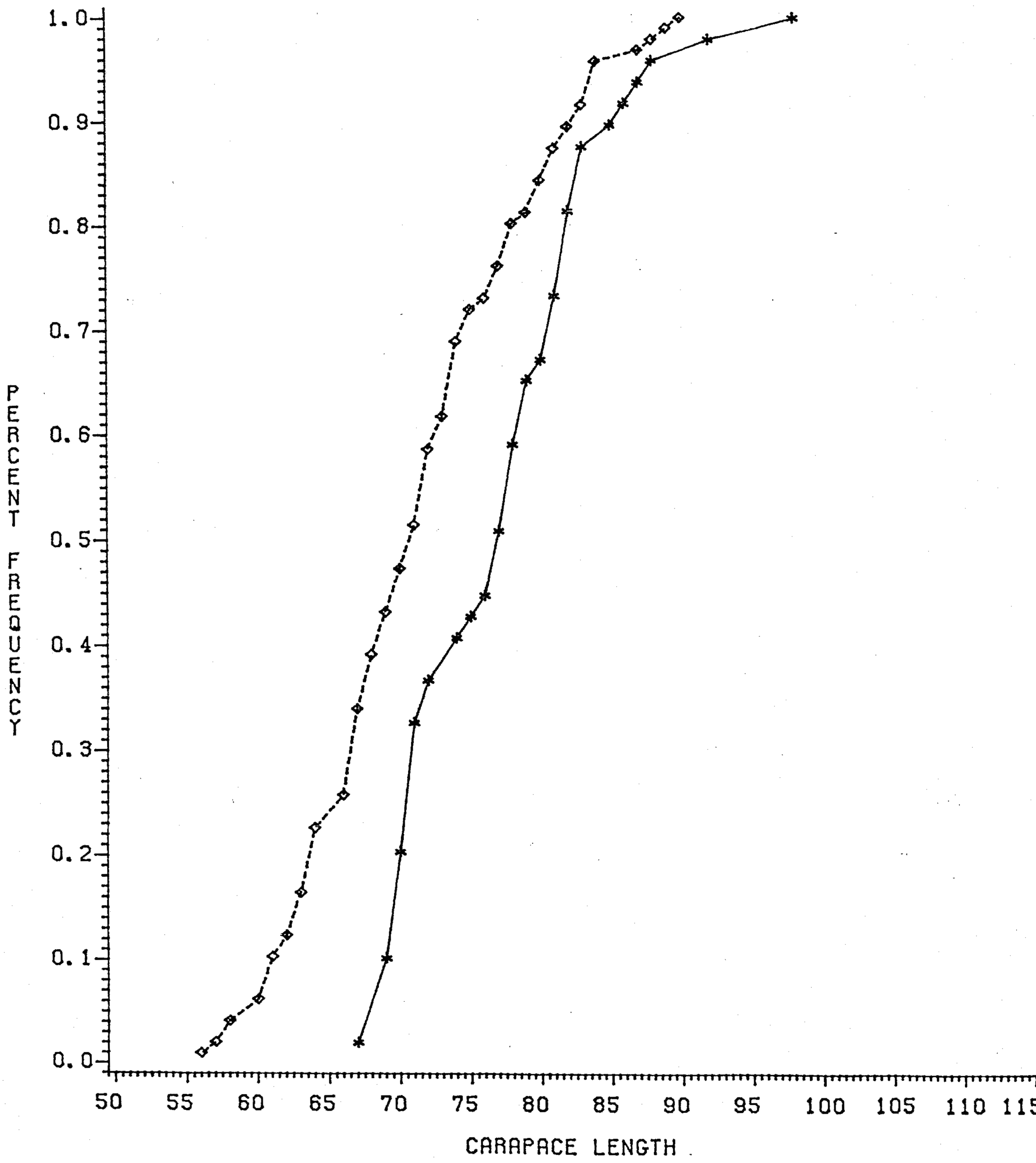

Figure 2.--Cumulative size composition of catches in wire and plastic traps for females at Necker Island.

WIRE TRAPS => SOLID PLASTIC TRAPS => DASHED

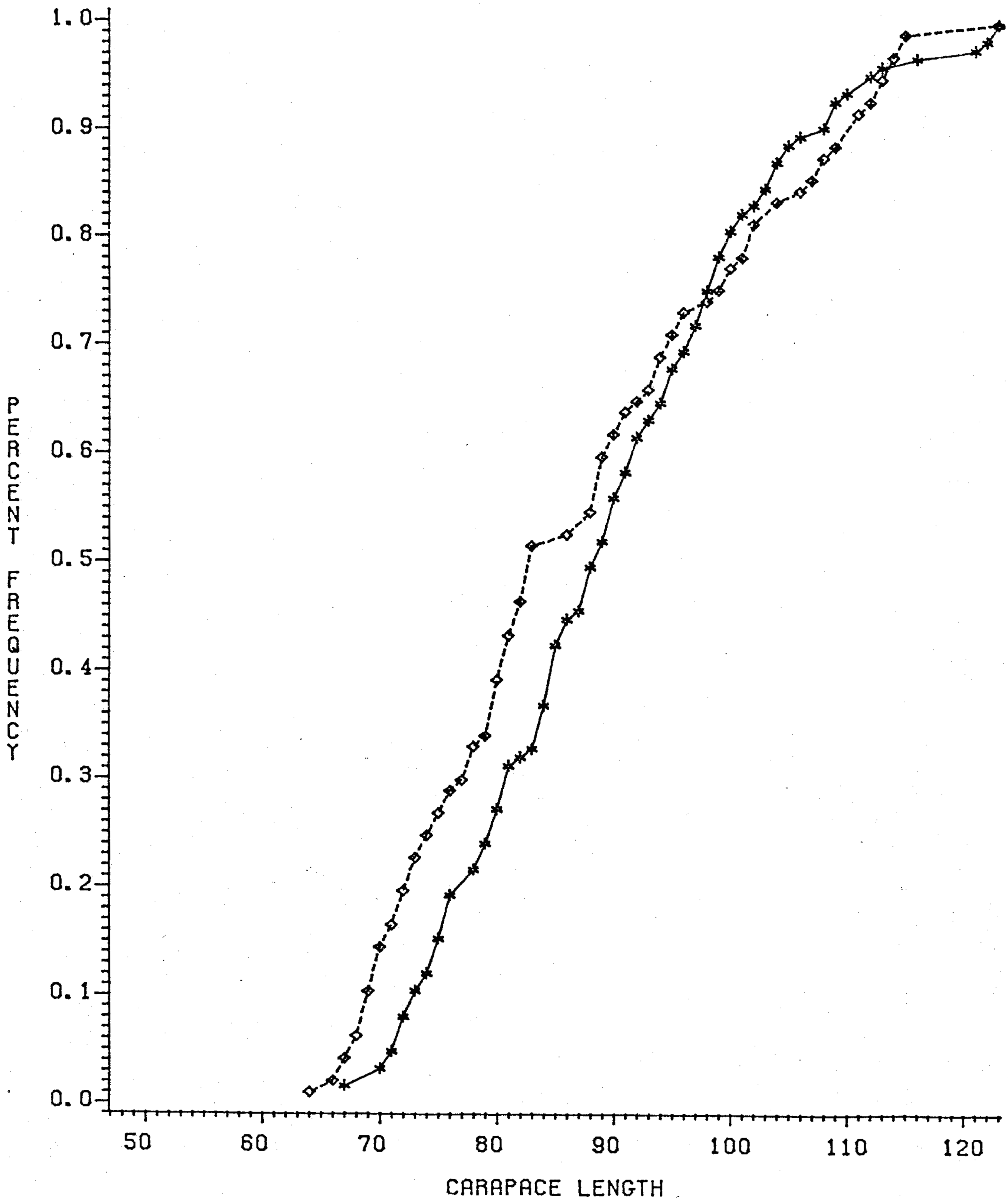

Figure 3.--Cumulative size composition of catches in wire and plastic traps for males at Maro Reef.

WIRE TRAPS => SOLID PLASTIC TRAPS => DASHED

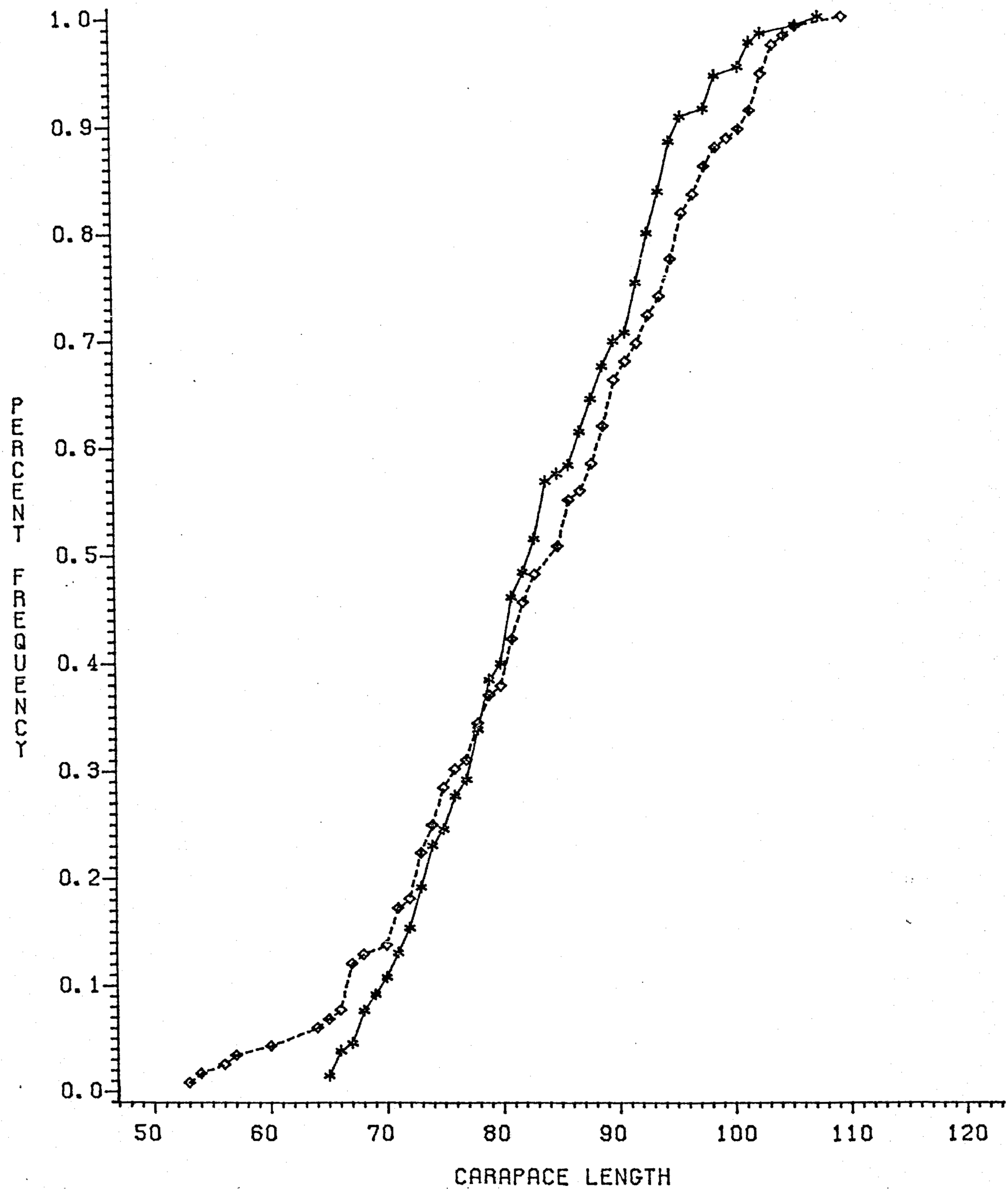

Figure 4.--Cumulative size composition of catches in wire and plastic traps for females at Maro Reef.

WIRE TRAPS => SOLID PLASTIC TRAPS => DASHED

Table 4.--Ratios of catch rates for wire and plastic traps in 1985.

Island or reef	Spiny lobster CPUE wire trap/ spiny lobster CPUE plastic trap (S.E.)	Slipper lobster CPUE wire trap/ slipper lobster plastic trap (S.E.)
Maro	1.09 (0.12)	0.15 (0.05)
Necker	0.34 (0.10)	0.02 (0.02)
Laysan	0.91 (0.14)	0.26 (0.04)

<7.7 cm whereas only about 50% of the spiny lobster caught in the wire traps are <7.7 cm CL (Figs. 1, 2). One reason for the higher proportion of small animals in the plastic traps is the retention of the smaller animals due to the smaller mesh size 5.1 x 5.1 cm (2 x 2 in.) used around the plastic traps compared with 5.1 x 10.2 cm (2 x 4 in.) wire used around the wire traps. This differential size specific catchability between plastic and wire traps explains why there is a difference in catch rates between the two traps at Necker Island which has a high proportion of small lobsters, and no difference in catch rates at Maro Reef and Laysan Island where the lobsters are on the average larger.

IMPLICATIONS FOR MANAGEMENT

1. The catch rates for slipper lobsters in wire traps remain unchanged from 1977 and are at a low level in absolute terms and relative to the black plastic traps. In light of the dramatic increase of slipper lobsters in the commercial landings, it is concluded that there has not been any change in species composition from spiny to slipper lobsters due to fishing, as has been suggested, but rather that the black plastic traps allow the fishermen to exploit a resource of slipper lobsters whose standing stock was not fully identified in earlier research and commercial fishing due to gear selectivity.

2. The standing stock of the harvestable population (legal under the FMP) at Necker Island is at 26% of its unexploited level and at 57% of its unexploited level at Maro Reef. The Schaefer surplus production model indicates that maximum sustainable production occurs when the total standing stock is maintained at 50% of its unexploited level. At Maro Reef the harvestable standing stock is at 51% of its unexploited level and at Necker Island the harvestable standing stock is at 26% of its unexploited level, suggesting that Maro Reef is probably fished near a level which produces the maximum yield whereas the Necker Island standing stock has probably been reduced below the level which provides maximum yield.

3. The standing stock of sublegal animals has been reduced to 74% of its unexploited level at Necker Island, 92% of its unexploited level at Maro Reef, and 71% of its unexploited level at Laysan Island. These

reductions at Laysan Island and Maro Reef are not statistically significant. It is not known whether the reduction of the sublegal population at Necker Island is statistically significant. If there has been a decline in the sublegal population it may be due to one or more factors including fishing mortality directed on the sublegal population due to a misperception by the fishermen that they can retain 15% of the catch with carapace lengths <7.7 cm. Other factors are the reduction of the spawning stock due to heavy fishing mortality on the legal animals, and mortality induced on the sublegal population as a result of being trapped and released. If it is due to a reduction of recruitment or due to capture and release induced mortality, the reduction of the sublegal population represents a loss to the fishery at Necker Island and may become a problem at other banks if fishing mortality increases and thus increasing the proportion of sublegals in the catch. In 1984 about 210,000 legal spiny lobsters were caught at Necker Island. Assuming that the 26% reduction in the sublegal population translates into 26% fewer legal-size animals, then for the same amount of fishing effort 26% fewer legal animals are landed. If the 1984 catch represents the catch under the conditions of the reduced sublegal population, then without the lower sublegal population the catch would have been 284,000 legal lobsters. If the sublegal population had only been recently reduced, so that this was not a factor in the 1984 catch, then under the reduced sublegal population and the same level of effort the 1984 catch would have been 155,000 legal lobsters. Even with the more conservative of the two estimates and at $5 a lobster this translates into a $275,000 annual loss to the industry at Necker Island.

4. Although the data collected from logbooks provide essential information about the level of catch, effort, and areas fished, the logbook data alone are not sufficient to understand the status of the resource. At the minimum, annual research cruises are needed to conduct standardized fishing and collect a time series of size-frequency and catch rate data.

5. Based on the estimates that fishing mortality is half natural mortality at Maro Reef and 1.5 natural mortality at Necker Island, and assuming that the size at which 50% of the population is sexually mature at both those islands is 7.0 cm CL, the Beverton and Holt yield equation can be used to estimate the change in the spawning stock biomass which would result when the minimum tail width is reduced from 5.1 cm (equivalent to 7.7 cm CL) to 4.8 cm (equivalent to 7.0 cm CL). At Necker Island under the existing level of fishing mortality, a reduction in tail width from 5.1 to 4.8 cm will reduce the spawning stock biomass to 70% of its level under the 5.1 cm tail width minimum size. If the level of recruitment is not reduced then the yield will increase by 15%. At Maro Reef under the current level of fishing mortality, a reduction of the tail width from 5.1 cm to 4.8 cm will reduce the spawning stock biomass to 86% of its level under a minimum tail width of 5.1 and increase the yield by 7%, if the recruitment is not reduced. For Maro Reef, which appears typical of most islands and banks in the NWHI, under the 5.1 cm minimum tail width regulation the spawning stock biomass is at 61% of its unexploited level. Thus a further reduction below the 4.8 cm tail width minimum will reduce the spawning stock to 52% of its unexploited level which is probably still sufficient to prevent recruitment overfishing. Thus it appears that the reduction of the tail width from 5.1

cm to 4.8 cm at Maro Reef, and most other islands and banks, will not be detrimental to the stocks and could increase the yield. The main caution is that, as the size of the harvestable population declines from fishing pressure, the proportion of animals below 4.8 cm tail width entering the traps will increase, and if mortality from capture and release of these animals is a factor, the reduction of the spawning stock biomass will be greater than has been projected and could result in recruitment overfishing. At Necker Island the problem of forecasting the impact of a reduction of the minimum tail width from 5.1 to 4.8 cm is more complicated because under the current high fishing pressure the spawning stock biomass is already at 34% of its unexploited level and there may have been a decline in the sublegal population. If the reduction in the sublegal population is statistically significant and is either due to direct fishing and retention of sublegals or mortality due to capture and release, then a reduction of the minimum tail width together with the use of escape gaps may not be detrimental to the stock. However, if the reduction in the sublegal population is due to a reduction in recruitment caused by a reduced spawning stock resulting from high fishing mortality, then a reduction of the minimum tail width from 5.1 to 4.8 cm will only further reduce the spawning stock and hence further reduce recruitment.

LITERATURE CITED

MACDONALD, C. D.

1984. Studies on recruitment in the Hawaiian spiny lobster *Panulirus marginatus*. *In* R. W. Grigg and K. Y. Tanoue (editors), Proceedings of the Second Symposium on Resource Investigations in the Northwestern Hawaiian Islands, Vol. 1, May 25-27, 1983, University of Hawaii, Honolulu, Hawaii, p. 199-220. UNIHI-SEAGRANT-MR-84-01.